INSTRUCTION MANUAL

MODEL 153

MICROVOLT-AMMETER

KEITHLEY INSTRUMENTS

RETURN TO:
FILE FOLDER
L-3140

INSTRUCTION MANUAL

MODEL 153

MICROVOLT-AMMETER

SECTION 1. OPERATION

1-1. GENERAL.

a. The Keithley Model 153 Microvolt-Ammeter is a versatile dc instrument with high input impedance and low noise for measuring a wide range of voltages and currents. It has 17 voltage ranges from 5 microvolts full scale to 1000 volts, and 21 current ranges from 10 picoamperes full scale to 100 milliamperes.

b. Input impedance is 200 megohms for the 1-millivolt and higher ranges. Input impedance at 10 microvolts is 20 megohms. If high input impedance is not needed, a front panel switch control allows shunting a 2-megohm resistor across the input.

c. Input noise on the most sensitive voltage range with the input shorted is less than 0.06 microvolt rms. Input noise on the most sensitive current range with the input open is less than 0.1×10^{-12} ampere rms.

1-2. FEATURES.

a. Accuracy for the voltage ranges varies from ±1% of full scale on the 3-millivolt and higher ranges to ±3% of full scale on the 10 and 30-microvolt ranges. Accuracy for the current ranges varies from ±2% of full scale on the 3×10^{-9} ampere and higher ranges to ±4% of full scale on the 3×10^{-11} ampere and lower ranges.

b. Careful shielding, filtering and guarding permit floating operation of the Model 153 in potentiometric null detector applications. Line frequency rejection of the Microvolt-Ammeter is good; a power line or twice power line frequency which is 40 db greater than full scale affects readings less than 0.5%.

c. The Model 153 uses the voltage drop method to measure currents. Input resistance as an ammeter varies from 1 megohm to 1 ohm. Voltage drop varies from 10 microvolts to 100 millivolts, depending upon the range used.

d. Recorder output is ±1 volt dc at up to 1 milliampere for full-scale meter deflection on any range. Output resistance is less than 10 ohms with the output potentiometer set for maximum output.

e. On the voltage ranges below 3 volts, momentary overloads up to 1000 volts will cause only temporary zero offset and instability. Prolonged overloads of 1000 volts on these ranges will increase noise and decrease the speed on the 10-microvolt range. On the ranges above 3 volts, 1000-volt overloads will cause no damage. Momentary overloads on any of the current ranges will cause only temporary zero offset and instability. Prolonged overloads will tend to damage the current sensing resistors.

1-3. APPLICATIONS.

a. As a versatile voltmeter, the Model 153 is ideal for measuring a wide variety of voltages such as contact potentials, vacuum tube electrode potentials, biologically generated emf's, electro-chemical potentials, and power supply voltages. Other applications include use with various voltage generating transducers such as piezo-electric generators, Hall effect generators and strain gauges.

b. The Model 153 is ideal for most null detector applications. On the three most sensitive ranges, power sensitivity is better than 5 x 10^{-21} watt. High ac rejection and excellent floating operation make the Model 153 an ideal null detector for any bridge or potentiometer.

c. The Model 153 is a wide-range ammeter for general use in research, design and production test facilities. It is ideal for making in-circuit measurements as well as measuring the output of various current generating transducers such as radiation detectors, photo-tubes. Leakage in tantalum capacitors and other components can be quickly and easily measured with the Model 153 and a Keithley voltage supply.

1-4. SPECIFICATIONS.

AS A VOLTMETER OR NULL DETECTOR:

RANGE:
Zero-left: 10 microvolts full scale to 1000 volts in 17 overlapping 1x and 3x ranges.
Zero-center: 5 microvolts full scale to 500 volts in 17 overlapping 5x and 15x ranges.

ACCURACY (exclusive of noise and drift):
±1% of full scale on 3-millivolt to 1000-volt ranges.
±2% of full scale on 100-microvolt to 1-millivolt ranges.
±3% of full scale on 10-microvolt and 30-microvolt ranges.

ZERO DRIFT: Less than ±2 microvolts per 24 hours after warm-up with reasonable constant ambient temperature. Less than 8 microvolts during 2-hour warm-up. Long term drift is non-cumulative.

INPUT NOISE: Less than 0.06 microvolt rms (0.3 microvolt peak-to-peak) on most sensitive range with input shorted. Less than 0.1 microvolt rms (0.5 microvolt peak-to-peak) on most sensitive range with 1-megohm source.

INPUT RESISTANCE:
Greater than 200 megohms on 100-microvolt to 100-volt ranges.
Greater than 50 megohms on 30-microvolt range.
Greater than 20 megohms on 10-microvolt range.
NOTE: Input resistance of any range may be shunted by a 2-megohm resistor using the FUNCTION Switch.

LINE FREQUENCY REJECTION: A power line or twice power line frequency which is 40 db (p-p/dc) greater than full scale affects reading less than 0.5%.

RISE TIME (10% to 90%):
Less than 1 second on 100-microvolt to 1000-volt ranges.
Less than 5 seconds on 10-microvolt and 30-microvolt ranges.

AS AN AMMETER:

RANGE:
Zero-left: 10^{-11} ampere full scale to 10^{-1} ampere in 21 overlapping 1x and 3x ranges.
Zero-center: 5 x 10^{-12} ampere full scale to 5 x 10^{-2} ampere in 21 overlapping 5x and 15x ranges.

ACCURACY (exclusive of noise and drift):
±2% of full scale on 3 x 10^{-9} ampere to 1 x 10^{-1} ampere ranges.
±3% of full scale on 1 x 10^{-10} ampere to 1 x 10^{-9} ampere ranges.
±4% of full scale on 1 x 10^{-11} ampere and 3 x 10^{-11} ampere ranges.

ZERO DRIFT: Less than ±2 x 10^{-12} ampere per 24 hours after warm-up with reasonably constant ambient temperature. Less than 8 x 10^{-12} ampere during 2-hour warm-up.

INPUT NOISE (with input open): Less than 0.1 x 10^{-12} ampere rms (0.5 x 10^{-12} ampere peak-to-peak) on most sensitive range.

INPUT RESISTANCE: Varies from one ohm on 10^{-1} ampere range to one megohm on 10^{-11} ampere range.

RISE TIME (10% to 90%)
Less than 2 seconds on 10^{-10} ampere to 10^{-1} ampere ranges.
Less than 5 seconds on 10^{-11} ampere and 3 x 10^{-11} ampere ranges.

GENERAL:

POLARITY: METER Switch selects left-zero (positive or negative) or center-zero scales. Recorder output polarity is not reversed.

ISOLATION: Circuit ground to chassis ground: Greater than 10^{9} ohms shunted by 0.05 microfarad. Circuit ground may be floated up to ±500 volts dc or peak with respect to chassis ground.

RECORDER OUTPUT:

Output: 0 to ±1 volt dc (adjustable) at up to one milliampere for full-scale meter deflection on any range.

Resistance: Less than 10 ohms with output potentiometer set for maximum output.

Voltage Gain: $\frac{\text{one volt}}{\text{Voltage setting in volts}}$

Noise: Input noise times voltage gain plus modulation products.

Modulation Products: Less than 5% peak-to-peak of full scale with input shorted.

CONNECTORS: Input: Special Triax. Output: Binding Posts.

POWER: 105-125 or 210-250 volts (Switch selected), 50 or 60 cps, 35 watts.

DIMENSIONS, WEIGHT: 10-1/2 inches high x 6-5/8 inches wide x 10 inches deep. Net weight, 13 pounds.

ACCESSORIES SUPPLIED: Model 1532 Low Thermal Test Leads (connector and 3-foot cable with alligator clips).

1-5. ACCESSORIES.

a. Model 1531 Gripping Probe with 3-foot cable is useful for making many measurements

for repeated measurements.

a. Model 1532 Test Leads consist of a connector, 3 feet of cable and alligator clips.

input receptacle and to accept Model 1534 Twist Cable.

sufficient for Model 153 usage. Other diameter of the Cable is 0.145 inch.

connections. The parts list is in Section 7.

in Model 1483 Kit. The parts list is in Section 7.

terminal and mating plugs for the input and output receptacles.

For measurements from low impedance sources, set the FUNCTION Switch to VOLTS, R-2M to reduce this pickup and to speed recovery from input overloads.

b. Refer to Table 1 for input resistance values for all voltage ranges.

2-5. CURRENT MEASUREMENTS. Set the FUNCTION Switch to the AMPS position. Use low resistance input connects to the current source to minimize the input voltage drop. Refer to Table 1 for the voltage drop by ranges and for the maximum allowable current overload.

Voltage Range	Input Resistance (megohms) with FUNCTION Switch set to		Current Range	Input Resistance	Voltage Drop	Maximum Current Overload
	R-2M	OPEN				
10 microvolts	≈1.8	≈20	10 picoamps	1 MΩ	10 μv	0.5 milliamp
30 microvolts	≈1.9	≈50	30 picoamps	1 MΩ	30 μv	0.5 milliamp
100 microvolts	≈2	≈200	100 picoamps	1 MΩ	100 μv	0.5 milliamp
300 microvolts	≈2	≈200	300 picoamps	1 MΩ	300 μv	0.5 milliamp
1 millivolt	≈2	≈200	1 nanoamp	1 MΩ	1 mv	0.5 milliamp
3 millivolts	≈2	≈200	3 nanoamps	1 MΩ	3 mv	0.5 milliamp
10 millivolts	≈2	≈200	10 nanoamps	1 MΩ	10 mv	0.5 milliamp
30 millivolts	≈2	≈200	30 nanoamps	100 kΩ	3 mv	1.6 milliamp
100 millivolts	≈2	≈200	100 nanoamps	100 kΩ	10 mv	1.6 milliamp
300 millivolts	≈2	≈200	300 nanoamps	10 kΩ	3 mv	5 milliamp
1 volt	≈2	≈200	1 microamps	10 kΩ	10 mv	5 milliamp
3 volts	≈2	200	3 microamps	1 kΩ	3 mv	16 milliamp
10 volts	≈2	200	10 microamps	1 kΩ	10 mv	16 milliamp
30 volts	≈2	200	30 microamps	100 Ω	3 mv	50 milliamp
100 volts	≈2	200	100 microamps	100 Ω	10 mv	50 milliamp
300 volts	≈2	200	300 microamps	10 Ω	3 mv	160 milliamp
1000 volts	≈2	200	1 milliamp	10 Ω	10 mv	160 milliamp
			3 milliamps	≈1 Ω	3 mv	500 milliamp
			10 milliamps	≈1 Ω	10 mv	500 milliamp
			30 milliamps	≈1 Ω	30 mv	500 milliamp
			100 milliamps	≈1 Ω	100 mv	500 milliamp

TABLE 1. Model 153 Voltage Input Resistances and Current Input Resistance, Voltage Drop and Maximum Current Overload by Ranges. Maximum Current Overload is the greatest current for the range which will not damage the range resistor.

MODEL 153 REPLACEABLE PARTS LIST

(Refer to Schematic Diagram 17771H for circuit designations.)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C101	0.1 µf	100 v	Poly	80164		C142-0.1M	
C102	0.1 µf	100 v	Poly	80164		C142-0.1M	
C103	0.1 µf	100 v	Poly	80164		C142-0.1M	
C104	.01 µf	200 v	Poly	84171	2PJ-103G	C108-.01M	
C105	.001 µf	1000 v	CerD	72982	801Z5V102P	C22-.001M	
C106	.01 µf	200 v	My	14655	WMF-2S1	C66-.01M	
C107	40/40/20 µf	450/450/50 v	EMC	56289	TVL3786	C33-40/40/20M	
C108	.047 µf	200 v	My	14655	WMF-2S47	C66-.047M	
C109	10 µf	15 v	EAl	56289	89D159	C93-10M	
C110	0.1 µf	200 v	My	02777	P-12M	C66-0.1M	
C111	.01 µf	1000 v	CerD	72982	811Z5V103P	C22-.01M	
C112	0.1 µf	100 v	My	12673	32M	C105-0.1M	
C113	10 µf	15 v	EAl	56289	89D159	C93-10M	
C114	.05 µf	100 v	My	12673	32M	C105-.05M	
C115	.05 µf	100 v	My	12673	32M	C105-.05M	
C116	.1 µf	200 v	My	02777	P-12M	C66-0.1M	
C117	.01 µf	200 v	My	14655	WMF-2S1	C66-.01M	
C118	0.5 µf	400 v	My	14655	WMF4P5	C114-0.5M	
C119	100 µf	15 v	EAl	56289	89D217	C93-100M	
C120	1.0 µf	200 v	My	13050	107-21	C66-1.0M	
C121	100 µf	15 v	ETB	56289	TE1162	C3-100M	
C122	.05 µf	1600 v	My-Paper	14655	DPMS1685	C87-.05M	
C201	.01 µf	400 v	My	14655	WMF4S1	C114-.01M	
C202	.01 µf	400 v	My	14655	WMF4S1	C114-.01M	
C301	80/40 µf	450/450 v	EMC	56289	2778	C36-80/40M	
C302	1000/1000 µf					C3-1000/1000M	
C303	100 µf	15 v	ETB	56289	TE1162	C3-100M	
C304	.001 µf	1000 v	CerD	72982	801Z5V102P	C22-.001M	
C305	.001 µf	1000 v	CerD	72982	801Z5V102P	C22-.001M	

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D301	Silicon	1N3256	02735	RF-22	
D302	Silicon	1N3256	02735	RF-22	
D303	Silicon	1N3253	02735	RF-20	

DIODES (Cont'd)

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D304	Silicon	1N3253	02735	RF-20	
D305	Zener	1N3022A	80164	DZ-23	

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
B101	Sodium Cell, 1.35 v (Mfg. No. PX-13)	37942	BA-16	
B102	Sodium Cell, 1.35 v (Mfg. No. PX-13)	37942	BA-16	
E101A	Photocell (Mfg. No. CL603CL)	03911	PD-4	
E101B	Neon Lamp (Mfg. No. A1C)	08804	PL-31	
E102A	Photocell (Mfg. No. C1603CL)	03911	PD-4	
E102B	Neon Lamp (Mfg. No. A1C)	08804	PL-31	
D103A	Photocell (Mfg. No. CL603CM)	03911	PD-5	
E103B	Neon Lamp (Mfg. No. A072)	74276	PL-32	
F1(117 v)	Fuse, slow blow, 0.5 amp, (Mfg. Type MDL)	71400	FU-4	
F1(234 v)	Fuse, slow blow, 0.25 amp (Mfg. No. 313.250)	75915	FU-17	
—	Fuse Holder (Mfg. No. 342012)	75915	FH-3	
GL101	Neon Lamp (Mfg. No. NE-2U)	08804	PL-14	
J1	Receptacle, Triaxial, INPUT (Mfg. No. 2676-1-NT34)	95712	CS-140	
—	Plug, Triaxial, Mate of J1	80164	Model 1533	
J2	Binding Post, DC OUTPUT (Mfg. No. DF21RC)	58474	BP-11R	
J3	Binding Post, LO (Mfg. No. DF21BC)	58474	BP-11B	
J4	Binding Post, GND (Mfg. No. DF21BC)	58474	BP-11B	
—	Shorting Link (Mfg. No. 938-L)	24655	BP-6	
L301	Choke, 2.5 mhy (Mfg. No. 6302-E)	76493	CH-7	
L302	Choke, 2.5 mhy (Mfg. No. 6302-E)	76493	CH-7	
M101	Meter	80164	ME-53A	
P1	Cord Set, 6 feet (Mfg. No. 4638-13)	93656	CO-5	
S1	Rotary Switch less components, RANGE	80164	SW-201	
—	Dial Assembly, Range Switch	80164	17026A	
S2	Rotary Switch, FUNCTION	80164	SW-199	
—	Knob Assembly, Function Switch	80164	18742A	
S3	Rotary Switch, METER	80164	SW-200	
—	Knob Assembly, Meter Switch	80164	18393A	

MISCELLANEOUS PARTS (Cont'd)

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
——	Knob, Zero Control	80164	16373A	
S4	Slide Switch, 117-234 v	80164	SW-151	
T1	Transformer	80164	TR-91	

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R101	10^9 Ω	20%, 1/2 w	Comp	75042	GBT	R37-10^9	
R102	270 kΩ	10%, 1/2 w	Comp	01121	EB	R1-270K	
R103	270 kΩ	10%, 1/2 w	Comp	01121	EB	R1-270K	
R104	270 kΩ	10%, 1/2 w	Comp	01121	EB	R1-270K	
R105	1 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1K	
R106	6.5 MΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-6.5M	
R107	2.2 MΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-2.2M	
R108	1 MΩ	1%, 1 w	MtF	07716	CEC	R94-1M	
R109	500 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-500K	
R110	*330 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-330K	
R111	47 kΩ	10%, 1/2 w	Comp	01121	EB	R1-47K	
R112	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	
R113	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	
R114	5.6 kΩ	10%, 1/2 w	Comp	01121	EB	R1-5.6K	
R115	2.2 MΩ	10%, 1/2 w	Comp	01121	EB	R1-2.2M	
R116	680 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-680K	
R117	4.7 kΩ	10%, 1/2 w	Comp	01121	EB	R1-4.7K	
R118	77.7 kΩ	0.5%, 1/2 w	MtF	07716	CEC	R61-77.7K	
R119	77.7 kΩ	0.5%, 1/2 w	MtF	07716	CEC	R61-77.7K	
R120	39.2 kΩ	0.5%, 1/2 w	MtF	07716	CEC	R61-39.2K	
R121	2.2 MΩ	10%, 1/2 w	Comp	01121	EB	R1-2.2M	
R122	47 kΩ	10%, 1/2 w	Comp	01121	EB	R1-47K	
R123	2.2 kΩ	10%, 1/2 w	Comp	01121	EB	R1-2.2K	
R124	100 kΩ	10%, 1/2 w	Comp	01121	EB	R1-100K	
R125	10 kΩ	10%, 5 w	WWVar	71450	AW	RP34-10K	
R126	2.7 MΩ	10%, 1/2 w	Comp	01121	EB	R1-2.7M	
R127	*4.7 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-4.7K	
R128	10 MΩ	10%, 1/4 w	Comp	44655	RC07	R76-10M	
R129	10 MΩ	10%, 1/4 w	Comp	44655	RC07	R76-10M	
R130	10 MΩ	10%, 1/4 w	Comp	44655	RC07	R76-10M	
R131	1 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1K	
R132	15 kΩ	10%, 5 w	WWVar	71450	AW	RP3-15K	

*Nominal value, factory set.

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R133	2 MΩ	5%, 1 w	Comp	01120	GB	R102-2M	
R134	100 MΩ	1%, 2 w	DCb	91637	DC-2	R14-100M	
R135	100 MΩ	1%, 2 w	DCb	91637	DC-2	R14-100M	
R136	196 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-196K	
R137	10 kΩ	20%, .2 w	CompV	71450	70	RP31-10K	
R138	1 MΩ	1%, 1 w	MtF	07716	CEC	R94-1M	
R139	100 kΩ	1%, 1 w	MtF	07716	CEC	R94-100K	
R140	10 kΩ	1%, 1 w	MtF	07716	CEC	R94-10K	
R141	1 kΩ	1%, 1 w	MtF	07716	CEC	R94-1K	
R142	100 Ω	1%, 1 w	MtF	07716	CEC	R94-100	
R143	10 Ω	1%, 1 w	MtF	07716	CEC	R126-10	
R144	1 Ω	1%, 1 w	MtF	07716	CEC	R128-1	
R145	680 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-680K	
R146	220 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-220K	
R147	68 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-68K	
R148	22 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-22K	
R149	6.8 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-6.8K	
R150	2.2 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-2.2K	
R151	680 Ω	10%, 1/4 w	Comp	44655	RC07	R76-680	
R152	220 Ω	10%, 1/4 w	Comp	44655	RC07	R76-220	
R153	100 Ω	10%, 1/4 w	Comp	44655	RC07	R76-100	
R154	95.3 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-95.3K	
R155	1 MΩ					RP13-1M	
R156	95.3 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-95.3K	
R157	1 MΩ	1%, 1 w	MtF	07716	CEC	R94-1M	
R158	1 kΩ					R127-1K	
R159	1.69 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-1.69K	
R160	1 MΩ	20%, .2 w	CompV	71450	70	RP31-1M	
R161	1.69 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-1.69K	
R162	100 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-100K	
R163	15 kΩ	10%, 1/4 w	Comp	44655	RC07	R76-15K	
R164	1 MΩ					R127-1M	
R165	332 kΩ					R127-332K	
R166	99 kΩ					R127-99K	
R167	32.3 kΩ					R127-32.3K	
R168	9 kΩ					R127-9K	
R169	2.33 kΩ					R127-2.33K	
R170	110 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-110K	
R171	11.8 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-11.8K	
R172	9.9 K					18613A	
R173	100					18613A	

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R174	3.01 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-3.01K	
R175	649 Ω	1%, 1/2 w	MtF	07716	CEC	R94-649	
R176	500 Ω	10%, 5 w	WWVar	71450	AW	RP34-500	
R177	100 kΩ	20%, .2 w	CompV	71450	70	RP31-100K	
R201	100 kΩ	10%, 1/2 w	Comp	01121	EB	R1-100K	
R202	220 kΩ	10%, 1/2 w	Comp	01121	EB	R1-220K	
R203	150 kΩ	10%, 1/2 w	Comp	01121	EB	R1-150K	
R204	1.5 MΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-1.5M	
R205	150 kΩ	10%, 1/2 w	Comp	01121	EB	R1-150K	
R206	1.5 MΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-1.5M	
R207	220 kΩ	10%, 1/2 w	Comp	01121	EB	R1-220K	
R208	100 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-100K	
R209	80 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-80K	
R210	25 kΩ	10%, 5 w	WWVar	71450	AW	RP34-25K	
R301	3 kΩ					R115-3K	
R302	30 Ω	10%, 5 w	WW	56289	57E	R96-30	
R303	2 kΩ					R115-2K	
R304	100 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-100K	
R305	1 MΩ	10%, 1/2 w	Comp	01121	EB	R1-1M	
R306	123 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-123K	
R307	50 kΩ	1%, 1/2 w	DCb	79727	CFE-15	R12-50K	
R308	33 Ω	10%, 1/4 w	Comp	44655	RC07	R76-33	

VACUUM TUBES

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
V101		80164	EV-12AU7	
V102		80164	EV-12AX7	
V103	12AT7	80164	EV-12AT7	
V201	12AU7	73445	EV-12AU7	
V301	0B2	86684	EV-0B2	
V302	0A2	86684	EV-0A2	

RANGE SWITCH POSITION	FUNCTION SWITCH POSITION 1 & 2 VOLTS F.S.	FUNCTION SWITCH POSITION 3 AMPS F.S.
1	10 UV	10 PA
2	30 UV	30 PA
3	100 UV	100 PA
4	300 UV	300 PA
5	1 MV	1 NA
6	3 MV	3 NA
7	10 MV	10 NA
8	30 MV	30 NA
9	100 MV	100 NA
10	300 MV	300 NA
11	1 V	1 UA
12	3 V	3 UA
13	10 V	10 UA
14	30 V	30 UA
15	100 V	100 UA
16	300 V	300 UA
17	1000 V	1 MA
18		3 MA
19		10 MA
20		30 MA
21		100 MA

NOTE:

1) ALL RESISTANCE AND CAPACITANCE SHALL BE DESIGNATED IN OHMS AND MICROFARADS RESPECTIVELY, UNLESS OTHERWISE NOTED.
2) ○ FRONT PANEL CONTROL
   ⊘ FRONT PANEL SCREWDRIVER ADJ.
   ⊘ REAR PANEL SCREWDRIVER ADJ.
   ⊘ INTERNAL SCREWDRIVER ADJ.
3) ∕ = C. W. ROTATION M = MEGOHMS
   P = PICOFARADS K = 1000 OHMS
4) ✳ INDICATES NOMINAL VALUE ADJUSTED AT FACTORY.
5. ▭ REFER TO VOLTAGE READINGS TAKEN WITH A 200 MEGOHM VOLTMETER.

MEASUREMENT CONDITIONS WERE AS FOLLOWS:

A. LINE VOLTAGE AT 117 V. A.C.
B. INPUT SHORTED
C. VOLTAGES TAKEN FROM LO WITH LINK CLOSED.
D. FUNCTION SWITCH AT 2M POS.
E. RANGE SWITCH AT 1V POS.
F. METER SWITCH AT + POS.
G. ±10% ON READINGS

HIGHEST REFERENCE DESIGNATION USED					REFERENCE DESIGNATION NOT USED				
R199	C130	V103	E103	M101	J10			R141	R127
R210	C202	V201				C127		R137	R126
R308	C305	V302	L302	D305		C123		R136	R125
						C122		R135	R124
			GL101	B102		C112	R180	R134	R123
						C108	R172	R132	R122
						C107	R167	R130	R120
						C106	R166	R129	R118
F1	P1	J4	T1	S4		C101	R142	R128	

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN	A.C.	DATE 3-9-61
FRAC. ± DEC. ANG.	CHK		DATE
± 1/64 ± .005 ± 1°	ENG APPR.		DATE
	PROJ. RELEASE		DATE
DO NOT SCALE	PROD. RELEASE		DATE

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE: SCHEMATIC

MATERIAL

FINISH

PART NUMBER 37017

KEITHLEY INSTRUMENTS, INC.
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